



Space Shuttle Debris Transport

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Debris Sources



Liftoff Debris
rust, uncontained
hardware, etc.



Foam, ice, gap fillers,
ceramic inserts, many
other smaller and lower
likelihood sources.

Ascent Debris

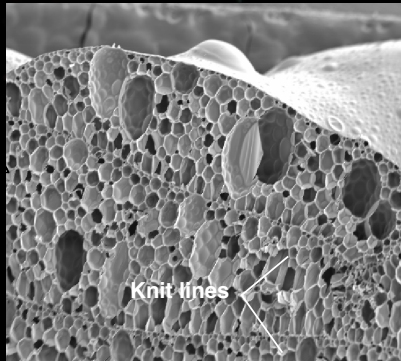


Orbital Debris
> 3 km/sec
> 9,800 ft/sec

Probabilistic Debris Process

$$\begin{aligned} Pr(failure) &= Pr(E_1 \cap E_2 \cap E_3) \\ &= Pr(E_1)Pr(E_2 | E_1)Pr(E_3 | E_1 \cap E_2) \end{aligned}$$

E₁ Debris Released



Void distributions,
material properties,
heating, etc.

E₂ Debris Impacts Surface



Flowfield, mass,
drag coefficient,
crossrange, etc.

E₃ Impact Exceeds Capability



RCC, tile, windows, ...
 $f(\text{mass}, \text{velocity}, \text{angle}, \text{material}, \dots)$

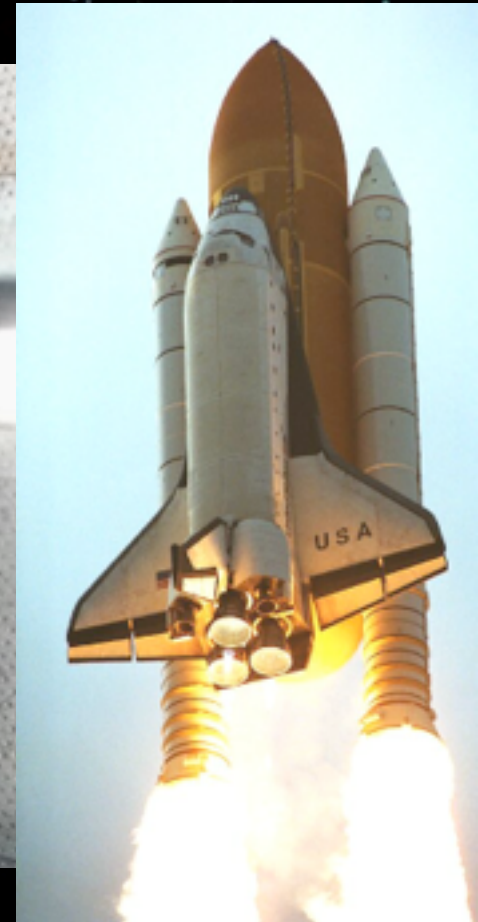
Engineering Tools



Modeling & Simulation



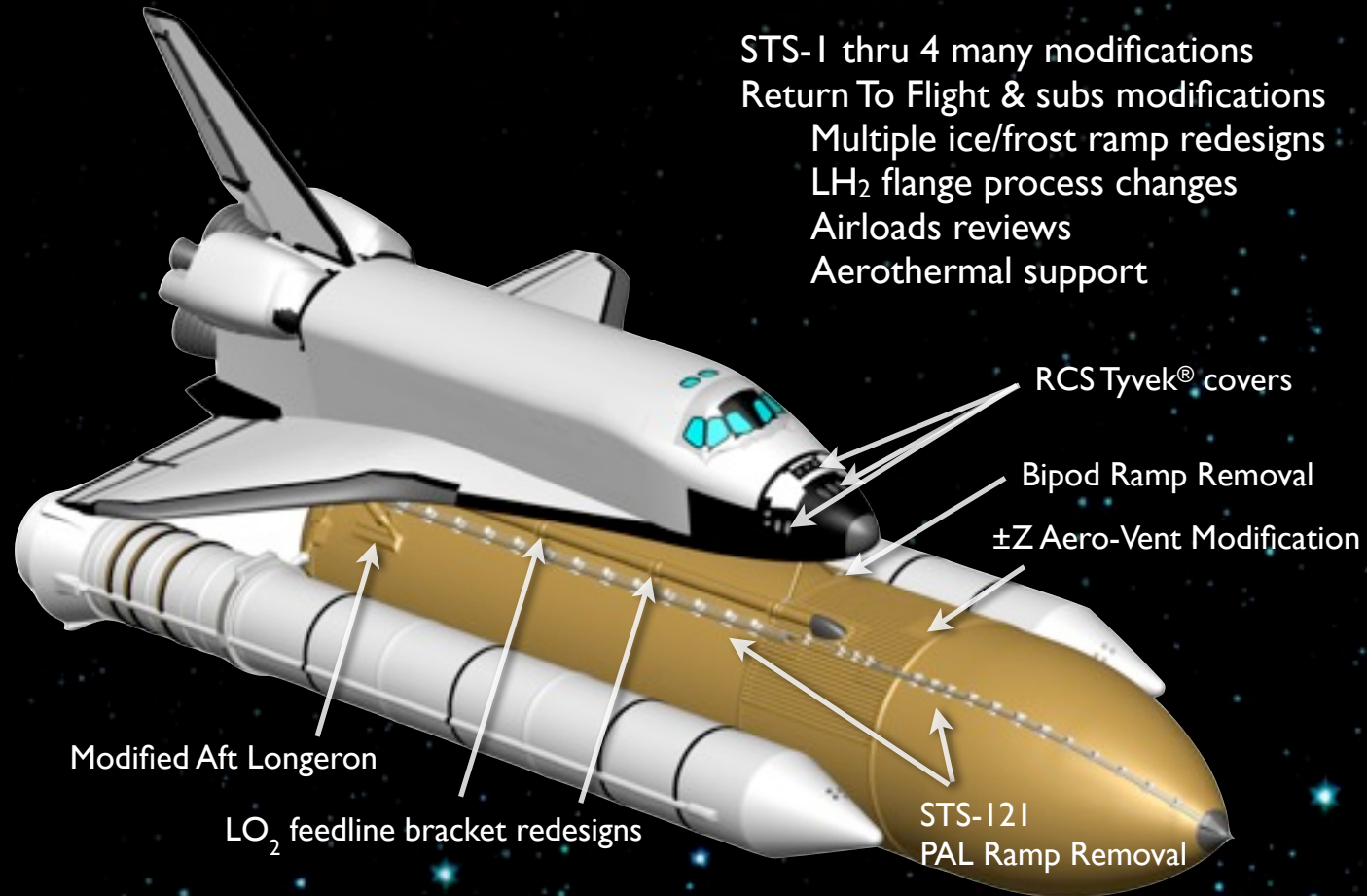
Ground/Subscale Test



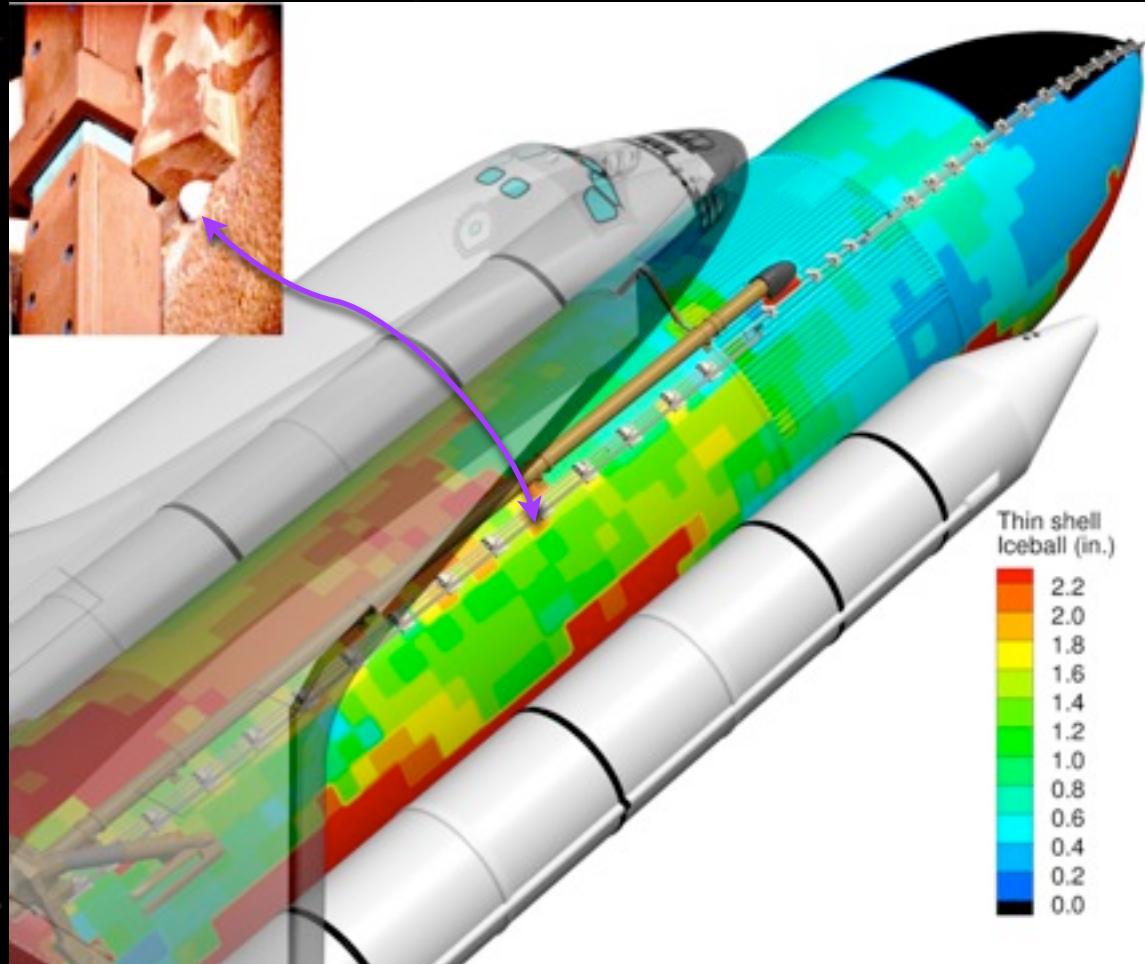
Flight/Full scale Test

Eliminating Debris Sources

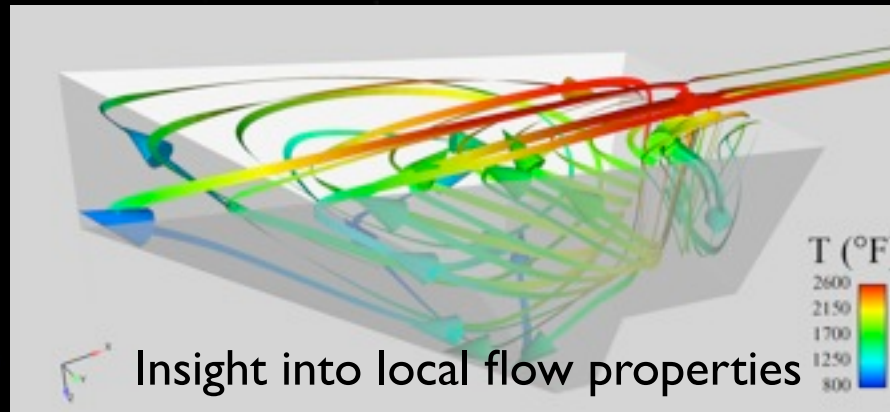
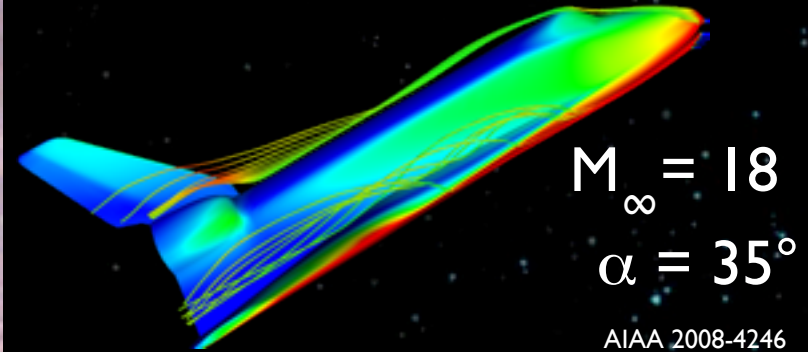
STS-1 thru 4 many modifications
Return To Flight & subs modifications
Multiple ice/frost ramp redesigns
LH₂ flange process changes
Airloads reviews
Aerothermal support



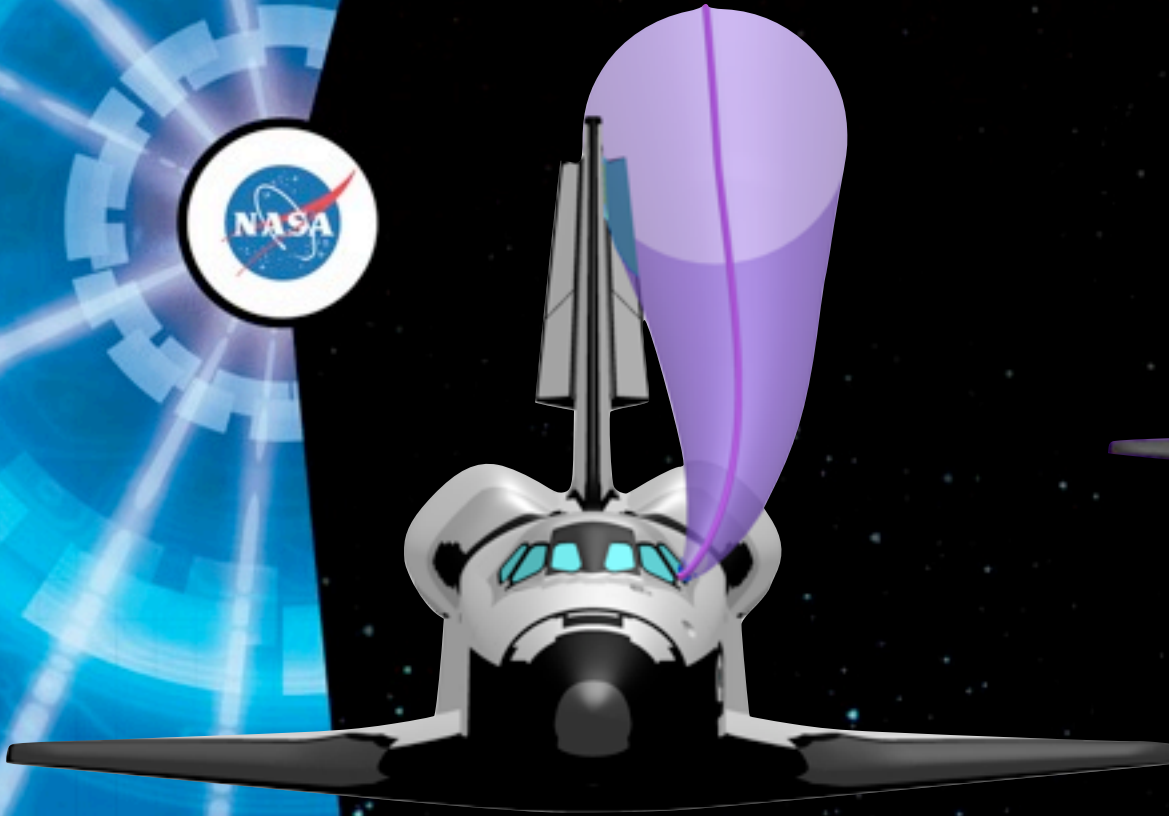
Prelaunch Iceball Assessment Tools



Inflight Damage Assessments



Inflight/Postflight Debris Assessments



Mach 3 Simulation of tile ceramic insert debris



Reaction Control System cover trajectory reconstruction

Computing & Oversight Space Shuttle Applications

